



Online article and related content
current as of April 19, 2010.

Weapons of Mass Destruction Events With Contaminated Casualties: Effective Planning for Health Care Facilities

Anthony G. Macintyre; George W. Christopher; Edward Eitzen, Jr; et al.

JAMA. 2000;283(2):242-249 (doi:10.1001/jama.283.2.242)

<http://jama.ama-assn.org/cgi/content/full/283/2/242>

Correction

[Contact me if this article is corrected.](#)

Citations

This article has been cited 61 times.
[Contact me when this article is cited.](#)

Topic collections

Bioterrorism
[Contact me when new articles are published in these topic areas.](#)

Related Articles published in
the same issue

Domestic Preparedness for Events Involving Weapons of Mass Destruction
[Joseph F. Waeckerle. *JAMA*. 2000;283\(2\):252.](#)

January 12, 2000
[JAMA. 2000;283\(2\):273.](#)

Subscribe
<http://jama.com/subscribe>

Permissions
permissions@ama-assn.org
<http://pubs.ama-assn.org/misc/permissions.dtl>

Email Alerts
<http://jamaarchives.com/alerts>

Reprints/E-prints
reprints@ama-assn.org

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 2000		2. REPORT TYPE		3. DATES COVERED 00-00-2000 to 00-00-2000	
4. TITLE AND SUBTITLE Weapons of Mass Destruction Events With Contaminated Casualties Effective Planning for Health Care Facilities				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Institute for Crisis, Disaster and Risk Management, Department of Medicine, US Army Medical Research Institute of Infectious Diseases, FT Detrick, MD				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 9	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Weapons of Mass Destruction Events With Contaminated Casualties

Effective Planning for Health Care Facilities

Anthony G. Macintyre, MD

Lt Col George W. Christopher, USAF, MC

COL Edward Eitzen, Jr, MC, USA

LTC Robert Gum, MC, USA

Scott Weir, MD

Craig DeAtley, PA-C

CDR Kevin Tonat, DrPH, MPH, USPHS

Joseph A. Barbera, MD

THE PERCEIVED THREAT OF chemical or biological weapons directed against the US civilian population has increased substantially.¹⁻³ The designation of these weapons, along with nuclear materials and high explosives, as “weapons of mass destruction” emphasizes their potential catastrophic effect on the health of a large population. Comprehensive communitywide management programs for civilians exposed to chemical or biological warfare agents are still under development and many response issues have not been fully addressed. Health care facilities (HCFs) are an integral yet often overlooked component of the overall community response.

Although response requirements differ for chemical and biological agent releases, in both cases there might be situations necessitating the removal of the agent from exposed individuals (decontamination). We discuss the planning of an effective HCF response to incidents that require decontamination of

Biological and chemical terrorism is a growing concern for the emergency preparedness community. While health care facilities (HCFs) are an essential component of the emergency response system, at present they are poorly prepared for such incidents. The greatest challenge for HCFs may be the sudden presentation of large numbers of contaminated individuals. Guidelines for managing contaminated patients have been based on traditional hazardous material response or military experience, neither of which is directly applicable to the civilian HCF. We discuss HCF planning for terrorist events that expose large numbers of people to contamination. Key elements of an effective HCF response plan include prompt recognition of the incident, staff and facility protection, patient decontamination and triage, medical therapy, and coordination with external emergency response and public health agencies. Controversial aspects include the optimal choice of personal protective equipment, establishment of patient decontamination procedures, the role of chemical and biological agent detectors, and potential environmental impacts on water treatment systems. These and other areas require further investigation to improve response strategies.

JAMA. 2000;283:242-249

www.jama.com

exposed persons. Such a response must be coordinated within the entire community response framework, as in the incident command system, the most widely accepted command and control model for emergency response in the United States.⁴ Events that are likely to challenge the decontamination capability of a HCF include 2 types of worst-case scenarios, chemical and biological.

With the release of a chemical weapon in a populated area, casualties may present en masse with little or no advance notification. The chemical agent deployed could be a traditional militarized agent (such as the vesicant mustard) or a more readily obtainable industrial hazardous material. As shown in the Tokyo sarin attack, a significant number of exposed individuals may find their own means of

transportation to the HCF unassisted by emergency medical services (EMS).⁵ These patients will not have undergone triage or decontamination, and the least injured will often present first. The HCF must have the ability to immediately decontaminate and treat those who are ill from the agent.⁶ Some persons may have

Author Affiliations: Institute for Crisis, Disaster and Risk Management (Dr Barbera) and Department of Emergency Medicine (Drs Macintyre and Weir and Mr DeAtley), George Washington University Medical Center, Washington, DC; US Army Medical Research Institute of Infectious Diseases, Fort Detrick, Md (Lt Col Christopher and COL Eitzen); US Army Center for Health Promotion and Preventive Medicine—Europe, Landstuhl Army Regional Medical Center, Landstuhl, Germany (LTC Gum); and the Office of Emergency Preparedness, US Public Health Service, Rockville, Md (CDR Tonat).

Corresponding Author and Reprints: Anthony G. Macintyre, MD, 2140 Pennsylvania Ave NW, Washington, DC 20037 (e-mail: emdagm@gwumc.edu).

For editorial comment see p 252.

experienced very little exposure to the agent, or none at all. They may still require decontamination because exposure cannot be ruled out. Symptoms may be accompanied by anxiety and may be diverse and confusing.^{5,7} Residual chemical agents on those exposed may pose a risk of secondary spread to the HCF and its workers by contact or vaporization.^{8,9}

In a biological attack, an infectious agent may be released surreptitiously and discovered after the incubation period, when patients present with illness. However, if a biological attack is announced or discovered publicly as it is occurring, it could result in large numbers of patients suddenly presenting for services. In contrast with chemical agents, most biological agents (except mycotoxins) are not dermally active or volatile. Reaerosolization of infectious particles is theorized to be a low but possible risk.¹⁰ Therefore, decontamination to lessen the effects of primary exposure and to prevent secondary exposure is less important than with chemical agents, but may be necessary.^{11,12} The procedure could be as simple as taking a shower and changing clothes (exposure to mycotoxins would call for procedures similar to those used for chemical agents, including extensive patient decontamination).¹³ A sudden biological event may require administration of prophylactic medications and vaccines and could place extraordinary demands on medical and public health staff and facilities.¹⁴⁻¹⁶ We do not address the epidemiological investigation and large-scale measures needed to control infection in the event a mass exposure to infectious agents is recognized in a delayed fashion. Plans for HCF response to these types of events are under development.^{11,17}

BACKGROUND

Until recently, any threat to civilians from hazardous materials (HAZMATs) primarily has come from industrial events.¹⁸ While unintentional releases are relatively common, they generally cause few serious toxic exposures per event.¹⁹ HAZMAT response guidelines have been developed and implemented for managing these incidents.²⁰

The unintentional release of militarized chemical agents from US military depots has been another civilian concern. In response, a major preparedness initiative, the Chemical Stockpile Emergency Preparedness Program, has been implemented in communities surrounding the depots.²¹ The response system has never been activated.²² No similar community preparedness program for biological release has been developed, since the US military ceased maintaining biological weapons in 1972.^{23,24}

The newly perceived threat entails the deliberate use of chemical and biological weapons against civilians. In many instances, these weapons are relatively easy to produce, inexpensive, and can be deployed covertly. Most significantly, the widespread terror caused by the use of these weapons could complicate response needs.^{25,26}

The toxic and psychological threats posed by chemical terrorism were demonstrated by the 1995 sarin attack in the Tokyo subway system.^{5,27} The assault resulted in 11 deaths and more than 5000 emergency medical evaluations, of which 73.9% had no identifiable clinical injury.²⁸ The majority of those exposed apparently had either a subclinical exposure or psychogenic symptoms. No chemical attacks of this nature have been reported in the United States.

No successful biological attack has occurred in the United States with an aerosolized agent, but other crimes and hoaxes involving biological agents have occurred.²⁹⁻³¹ The potential psychological effects of bioterrorism were demonstrated by the 1997 B'nai B'rith incident in Washington, DC.³² A Petri dish found in the mail room of the B'nai B'rith headquarters was labeled to indicate the presence of *Bacillus anthracis* and *Yersinia pestis*. Responders and incident managers were unaware that nonaerosolized, agar-based organisms pose no inhalation or cutaneous exposure hazard (it was later proven that neither organism was present). As a result, an expensive scene-control operation took place, causing fear and inconvenience among those potentially exposed. Other recent biological hoaxes

have also disrupted communities across the country.³³

CURRENT CAPABILITY

As the potential threat of civilian exposure increases, the new challenge for the medical emergency response community will be managing contaminated mass casualties, some of whom may be ill. Many HCFs are poorly prepared for the decontamination requirements of even small-scale HAZMAT incidents,^{34,35} as demonstrated by the temporary closures of well-run, full-service emergency departments after presentation of only 1 or 2 contaminated patients in 1997.³⁶ The most comprehensive HCF response plans to date were designed to cope with specific individual chemical or biological agents and radioactive nucleotides.³⁷

Development of HCF response plans has been hampered by many factors. Foremost is the lack of civilian experience with mass casualty events of a chemical or biological nature. Many civilian plans are derived from the experiences of prehospital HAZMAT response teams or military defense procedures that may not be appropriate.

The HAZMAT approach assumes that responders will enter a highly toxic environment near the source of release (away from an HCF). Maximum protection is provided for a few workers rescuing a small number of patients, usually without time pressure for decontamination. The primary objectives are scene containment and environmental protection. In line with these assumptions, the Occupational Health and Safety Administration (OSHA) has mandated the use of a "Personal Protection Level based upon site hazards."³⁸ However, site hazards are more easily defined at the point of release than at the HCF, where patient care is conducted. Thus, current OSHA guidelines may be inappropriate for HCFs. Traditional HAZMAT products, such as decontamination tents, trailers, and isolation rooms, are expensive, require prolonged setup time, or are inadequate for large numbers of patients.³⁹

Military countermeasures for chemical and biological weapons are also inappropriate for civilian use without modi-

fication. Military personnel are a more homogenous population, generally physically fit, mentally disciplined, and equipped for chemical warfare. Because they are designed for operations in very toxic environments, military contingency plans can be complex.⁴⁰ Incorrect civilian use of military protective equipment and decontamination procedures may be hazardous, as with the use of military-style gas masks by Israeli civilians during Gulf War missile attacks. Fatalities resulted from improper mask use.^{41,42}

The US government has recently begun addressing civilian preparedness deficits. A 1995 presidential initiative funded the prototype for Metropolitan Medical Strike Teams,⁴³ which were composed of specially trained local personnel were organized to help communities respond to events. This effort has been revised to include a systems approach and has been renamed Metropolitan Medical Response Systems (MMRS). The overall goal of the MMRS program is to link first-response, public health, and health care systems. As a component of the MMRS, HCFs will remain responsible for initial management of contaminated patients. To date, 47 urban areas have received funding for development of an MMRS and more communities are expected to receive similar support.

The Nunn-Lugar-Domenici congressional legislation allocated federal funds to the Department of Defense to upgrade the capabilities of civilian first responders, including HCF personnel.⁴⁴ This Domestic Preparedness Program is being conducted serially in 120 metropolitan areas by the US Army Soldier and Biological Chemical Command.⁴⁵ This program is intended to provide operational-level preparedness, with educational tracts for community response entities, including emergency management, law enforcement, fire, and medical personnel. The current program for hospital personnel has lacked detailed operational methods.^{46,47} A large-scale chemical agent exercise in New York City, conducted after hospital personnel had participated in the Domestic Preparedness Program, demonstrated that hospitals would still have difficulty managing patient decontamination.⁴⁸

The federal government has established a National Domestic Preparedness Office (NDPO) under the auspices of the Department of Justice to act as a clearing house during responses to domestic chemical and biological terrorist incidents. The NDPO will handle information pertinent to law enforcement, emergency medical response, medical, and public health sectors.

Federal preparedness initiatives have been paralleled by private industry's development of chemical and biological agent response products and training programs. Self-described expert consultant groups offer risk analysis and training for various components of local emergency response, including HCFs. Some programs market equipment packages supplied by vendors working in conjunction with the consultants.⁴⁹ Most offer operational guidelines based on traditional HAZMAT procedures. As yet, no published large-scale exercise or response experience has validated these programs.

PROPOSED HCF CONCEPT OF OPERATIONS

Owing to the complexity of a civilian event involving chemical or biological weapons, HCFs should begin by delineating priorities that guide their preparedness process. These objectives should be established in coordination with the other members of the community involved in emergency response. The priorities of the HCF could be ranked in this order: (1) protection of the current patients, staff, and facility; (2) provision of the best possible medical care for contaminated patients presenting to the institution for care; and (3) environmental protection external to the HCF. In a large-scale event, containment of wastewater will probably be impossible, though no consensus has yet been reached on this controversial point. This issue should be addressed through comprehensive planning that includes local environmental and water authorities.

Certain assumptions can be made to simplify planning. One is that the exposure site is remote from the HCF (ie,

the HCF is receiving patients but is not within the primary release area). Otherwise, facility evacuation or "sheltering in place" may be indicated. Key components of the model preparedness plan are illustrated in the FIGURE.

Event Recognition

In an unannounced event, it is essential to recognize contaminated patients before their entrance into the facility. Security personnel must be trained in early recognition and should be stationed at the hospital entrances. Security personnel should immediately notify management personnel when they suspect a problem, and they should be prepared to protect themselves by donning personnel protective equipment (PPE). Even so, it is reasonable to expect some contaminated individuals may gain entrance into the facility. These situations should be handled on a case-by-case basis with a rational approach. It will not be necessary to completely seal off the facility or a department in most circumstances.⁵⁰

Activation of Plan

The alert mechanism should be expeditious: PPE must be immediately accessible to decontamination and patient care personnel, and the decontamination facility should be operational within 2 to 3 minutes.

Management

The principles of the incident command system should be incorporated into the HCF's emergency preparedness plan.⁵¹ The use of this system will enable HCF staff to fully integrate their activities with community emergency response assets, since it is widely used by fire, EMS, and police personnel as well as many state and federal agencies. Although initial response efforts will be centered in the decontamination and treatment areas, other HCF departments will play vital roles. For instance, security officers must direct the flow of casualties and vehicles to prevent facility compromise and must prevent unauthorized access to the decontamination and treatment areas.

Personnel from departments including emergency, critical care services, plant operations, pharmacy, supply services, infectious disease, respiratory therapy, laboratory, and toxicology must be targeted for education and training in the response plan.

A widespread chemical or biological incident will result in extended operational periods. Staff should be coordinated to provide relief from physically taxing activities such as patient decontamination. Providing food and hydration in a hygienic manner will enhance staff performance. Psychological support for staff should be available.

Personnel caring for contaminated patients should be properly outfitted in PPE. Specific data to determine the appropriate level of hospital worker protection remains limited, and a recent extensive review on chemical and biological terrorism published by the Institute of Medicine is inconclusive on this issue.⁵² Level C PPE consists of a non-encapsulated, chemical-resistant suit, gloves, and boots, with a full-face air purifier cartridge mask (powered or non-powered). This gear should afford adequate respiratory protection for outdoor exposure to contaminated chemical casualties who have survived transport to the HCF.^{21,53} For HCF workers conducting decontamination of patients acutely contaminated with infectious biological agents, level D protection (standard work clothes) plus latex gloves, eye splash protection, and N-95 respiratory masks (used in many hospitals for protection against tuberculosis) should be adequate.^{54,55} If responders are concerned about reaerosolizing an agent during clothing removal, a high-efficiency particulate air (HEPA) filter mask could be added. If the agent class for a sudden release cannot be identified, level C PPE with an organic vapor/HEPA filter cartridge mask is recommended.

Training is essential for the correct use of PPE. Work times and conditions must be monitored while personnel are using PPE to prevent fatigue or heat stress. Personnel should be rotated if decontamination operations are prolonged. Once patients have been decontami-

nated, they may be handled by staff using universal precaution guidelines.

Crowd control will require firm, authoritative direction from hospital security and, if available, police or the National Guard. Since PPE face masks muffle the voice, loudspeakers should be provided to personnel directing contaminated patients. Signs designating functional areas and providing patient instructions should be in place.

Primary Triage

All exposed and potentially exposed individuals should receive an initial brief triage, performed by medical personnel in PPE, before decontamination. They should then be directed to 1 of 2 areas, nonmedical decontamination or medical decontamination. The uninjured, those with minor injuries requiring no medical intervention during decontamination, and the majority of ambulatory patients will be assigned to nonmedical decontamination. These individuals may require nonmedical assistance with washing themselves (eg, unaccompanied children, persons in wheelchairs, and those with other special needs). Those with injuries or illness poten-

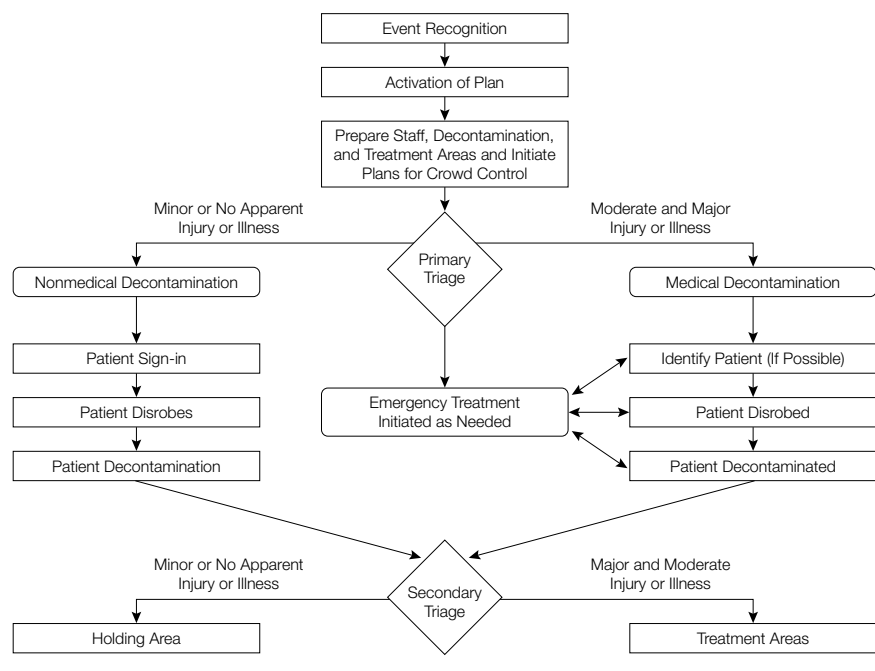
tially requiring medical intervention will be assigned to medical decontamination by staff.

Throughout the decontamination process, attention must be given to symptoms of exposure to chemical or biological agents that may indicate early life-threatening deterioration (eg, a sore throat or mild shortness of breath after exposure to pulmonary or laryngeal irritants).

Patient Sign-in/Identification and Securing Property

A brief sign-in process should capture name and date of birth (full registration can occur after decontamination and should be consistent with the community patient tracking system). A number on a log can be assigned to each patient, who would receive 2 identically numbered plastic bags and a nonpermeable wristband. Clothing would be placed into the larger clear, impervious bag. Separation of valuables into the second, smaller bag would enhance the security of these items. A meticulous, practical method of cataloging belongings will ensure their return and possibly assist in forensic investigations.

Figure. Health Care Facility Response Plan for Chemical or Biological Weapons Release



Patient Decontamination

The HCF should possess partially fixed or preconstructed decontamination facilities that can be activated immediately. This facility should be designed to occupy little storage space and not disrupt routine operations while in use. The Israeli model, developed during the Gulf War, consists of showers permanently fixed to the ceiling structure of an open-air parking garage or the side of a building.⁵⁶ The George Washington University Hospital model uses fire exit alleyways. An outdoor decontamination facility can prevent entry of contaminants into the HCF and obviates dedicating space with room ventilation and vapor isolation. An outdoor facility is also more suitable for the influx of mass casualties. Outdoor decontamination, however, must offer protection from inclement weather and have adequate lighting for night operations.

Because clothing will be removed before decontamination, privacy must be protected to ensure compliance with full decontamination. The sexes should be separated, with a visual barrier between shower lines. The need for protection of privacy was demonstrated by a successful lawsuit against a fire department whose personnel decontaminated 2 women without ensuring adequate privacy.⁵⁷

Another important consideration is rapid patient progression through the decontamination process. Traditional HAZMAT decontamination is passive (using 2 responders to clean each patient), which is time consuming and unnecessary for the majority of ambulatory patients in the nonmedical decontamination area. Promoting patient self-decontamination will significantly decrease the required number of health care workers. Of course, decontamination assistance for some patients in the nonmedical decontamination area and full passive decontamination in the medical decontamination area must still be available.

Decontamination facilities should contain multiple shower stations that are designed to allow patients to progress at various rates without com-

promising overall flow. Patients whose clinical condition deteriorates in the decontamination line can impede the progress of others. Plans must include means for sidetracking these patients into an area separate from the main decontamination sites, where treatment can be initiated.

Decontamination can be accomplished by using a sequential copious warm water rinse, a hypoallergenic liquid soap wash, another warm water rinse, and then a final rinse after walking past other in-use showers. Incapacitated patients will require soap and water cleansing by staff, with attention to washing and rinsing the patient's back and the nonabsorbent backboard. The water temperature must be adjustable. Excessively warm water should be avoided, as this may promote peripheral vasodilation and toxin absorption. Stiff brushes or abrasives should also be avoided as they may enhance dermal absorption of the toxin and can produce skin lesions that may be mistaken for chemical injuries.^{58,59} Sponges and disposable towels are affordable and effective alternatives.

Secondary Triage

Persons with major or moderate casualties would be referred to treatment areas designated for such cases. Those with minor or no apparent injuries should be sent to a holding area for further evaluation, observation, and eventual treatment if needed.

Holding Area

Large spaces such as cafeterias or auditoriums can be used for observation of large numbers of patients with minor or no apparent injuries and illnesses by physicians and nurses. At this time, HCF staff should also provide information on the agent involved, potential short- and long-term effects, recommended treatment, stress reactions, and possible avenues to further assistance. It is essential to provide important information in writing because the memory of patients may be impaired by the psychological stress of dealing with an exposure. All potentially exposed individuals should also be enrolled in a

long-term surveillance program to monitor possible health effects.

Logistics for Treatment

Specific therapies for chemical and biological agent casualties vary according to the etiologic agent and are described elsewhere.^{15,16,60,61} Mass casualties requiring specific chemical antidotes, vaccinations, or antibiotics will quickly deplete available supplies. In most cases, current hospital stocks of medications would be inadequate to meet the needs of even a few of these patients.⁶² Several efforts are under way to address this problem, including a federal initiative to stockpile antibiotics and vaccines.⁶³ Other concerns have not yet been adequately addressed. After a smallpox release, for example, postexposure vaccination might be indicated, but smallpox vaccine is no longer produced and current stocks are limited.^{16,64}

Otherwise straightforward medical problems, including eye injuries, bronchospasm, and burns, may also need mass intervention. Ventilators and other critical care supplies may be needed in large quantities. This problem could be resolved in part through mutual aid agreements between HCFs. Such an agreement established in the Washington, DC, area provides for pooling of resources (including personnel, supplies, and equipment), and sharing of information.⁶⁵ Contingency plans of this type may be vital to saving lives, since time constraints prevent reliance on resupply support from state and federal agencies during the initial crucial period of an event.

Epidemiological Considerations

Health care facility involvement will extend beyond the treatment of patients who are acutely ill or exposed. A comprehensive community response will include epidemiological analysis undertaken by local and national public health organizations to identify all potential exposed individuals. This should be done during the brief interval when early intervention can save lives and containment can reduce secondary transmission of contagious agents. Such

analysis will require participation by HCFs.

Information Resources

Health care facility personnel must identify sources of expert information on chemical and biological agents to ensure ready access to such information. Ideally, a repository or data bank could be established at the community or national level. This would allow for the distribution of uniform information.

Other resources include medical management handbooks developed by the US Army's chemical and biological defense medical laboratories.^{54,60,61} Some civilian-based protocols, such as pediatric recommendations, have also been established; these are currently being revised by the US Public Health Service.⁶⁶ Consensus statements organized by the Working Group on Civilian Biodefense also provide useful guidance.^{15,16} Consultation is also available 24 hours a day by remote access through the National Response Center at (800) 424-8802.

Public Information

Prompt attention must be given to information issued to the public through the news media and bulletins. Media inquiries must be carefully handled, and the content of these communications should be discussed with appropriate emergency management authorities to prevent the release of conflicting or erroneous reports.

Postincident Actions

Following the event, HCF management should conduct an incident review with hospital personnel involved in the emergency response. The purpose of such a review is to determine, in a nonpejorative manner, the sequence of events and to disseminate the rationale behind controversial decisions. Exposure risks and necessary countermeasures should be discussed to alleviate some of the psychological impact of incident stress. The incident critique, which will take place later, is a technical review designed to evaluate and improve the response plan. The

staff should also have access to formalized stress debriefing at a later date.

Because injuries and illnesses sustained during the response would be covered under employee compensation insurance, all staff members involved should be registered in a health surveillance program. This will ensure that medical issues will receive proper attention, and demonstrate the HCFs commitment to employee health. In view of the possible delayed or chronic effects of some chemical agents, surveillance could continue for years. Assistance for this type of surveillance is available through the Agency for Toxic Substances and Disease Registry, which the US Department of Health and Human Services has identified as the lead agency for the registration of personnel exposed to chemical or biological warfare agents.⁶⁷

It will be essential to clean the decontamination facilities and process the possessions of contaminated patients, as well as dispose of solid waste. Cleanup will be guided by the specific agent involved and the law enforcement investigation. If no adequate, financially viable method is available to inactivate a highly toxic, persistent agent such as the nerve gas VX, assistance may be required from other local, state, or federal entities.⁶⁸

CONTROVERSIES AND RESEARCH REQUIRED

Personal Protective Equipment

One major question concerns the optimal approach to PPE. To simplify guidelines and reduce confusion about the variety of choices, PPE recommendations could be standardized. This measure would ease financial disincentives as well as training requirements. Although published research on adequacy of PPE is limited, the consensus emerging among researchers and medical planners is that level C protection (using a full-face mask with powered or nonpowered canister filtration system) is adequate for HCF workers.^{21,68,69} A few reports recommend a higher level of protection, level B, which includes a mask supplied by an exter-

nal air source (hose-supplied air with an escape cylinder or a self-contained air tank).⁷⁰ However, these reports do not mention whether higher levels of protection produce a quantified increase in safety, nor do they discuss the possible disadvantages such as additional cost, weight, and training requirements.

Choosing a specific material to provide chemical barrier protection for HCF personnel is difficult. Many types of chemically resistant suits are available. They vary in cost and each has unique properties.⁷¹ Industrywide testing is based on permeation rates of pure substances directly applied to the material, but such data may not be relevant to the exposure in the HCF response model.⁷² Health care workers remote from the impact site or incident scene will be exposed only to the agent that remains on the skin and clothing of those exposed, so concentrations of substances encountered during decontamination at the HCF will be more dilute than concentrations used for the testing PPE materials.⁶⁸ Less expensive barrier materials may therefore be adequate.

Decontamination Solution

Another controversial concept concerns patient decontamination. Should decontamination be simplified by establishing a universal process for all incidents, as suggested by Cox?⁷¹ Some authors have already published universal decontamination protocols for chemical exposures.⁵⁰ There is little argument that soap and water will be effective for most agents. In the past, an agent neutralizer such as a 0.5% solution of hypochlorite was recommended. It inactivates biological agents (except mycotoxins) and, at a slower rate, chemical agents such as mustard and organophosphates.^{13,60,61} The studies indicate, however, that 15 to 20 minutes of contact time is necessary for hydrolysis or oxidation and, thus, for the inactivation of chemical agents.⁶⁰ Furthermore, dilute bleach can cause tissue damage in open wounds, exposed nerve tissue, and the eyes.^{13,73} The lack of clear safety and efficacy data for bleach decontamination suggests that

it should be avoided, especially if soap and water are immediately available. There may be rare exceptions to a universal decontamination process. For instance, pure metals and strong corrosives require dry decontamination (ie, gentle brushing or vacuuming of larger particles) before water is applied.^{68,74}

Agent Detectors

Yet another controversial issue is what role agent detectors should play in an HCF response plan. Agent detectors and monitors are used in the military and HAZMAT/EMS arenas. In the HCF environment, however, they would only complicate and lengthen the decontamination process. Much of the monitoring and detection equipment for chemical and biological agents is expensive and training intensive. Even handheld assays require attention to standard protocols. Moreover, some agent detectors can give false-positive readings when perfume, diesel vapors, or nonthreatening contaminants are present.⁷⁵ In some cases, cool air, the presence of a non-militarized agent, or other factors can produce false-negative results. Detection can also be time consuming. If an HCF is operating without any means of detection, HCF personnel must consider that most biological agents and some selected chemical toxins (eg, mustard) have delayed clinical manifestations. Contingency plans must include the capability to treat potentially exposed persons, if indicated, while confirmatory tests are under way.

Decontamination Wastewater

Questions have also been raised about the potential environmental impact of releasing decontamination wastewater into the water treatment system. To date, the Environmental Protection Agency has not published an official statement on this issue in relation to HCF planning. The decision not to contain wastewater can be justified for most agents in a life-threatening mass casualty situation. Biological agents may pose only a temporary risk to the environment or to the people in the area because of rapid environmental degradation or difficult

reaerosolization.^{10,13} On the other hand, a large-scale chemical incident usually results in significant environmental pollution; the amount of agent borne by patients presenting to HCFs will constitute only a small fraction of the total environmental burden. Some authors suggest that as much as 75% to 90% of the hazardous agent may be removed by disrobing.^{70,71,75} The remaining skin contaminant may be minuscule and can be diluted further during washing and passing into public wastewater systems. The installation of a large-volume wastewater containment system is a prohibitively expensive undertaking. Even if installed, the final disposition of wastewater containing hazardous materials can be a catastrophic financial burden. If the facility design does not provide wastewater containment, appropriate water authorities should be notified at the time of the event.

Unanswered Questions

These and other pressing questions must be investigated if research is to help improve response strategies:

- What are the actual risks to first responders, clinicians, and other health care workers from reaerosolizing biological agents on contaminated clothing, skin, or environmental surfaces?
- What is the minimum adequate amount of washing/rinsing time required for adequate decontamination from most agents?
- What are the specific limitations of level C and level B PPE for HCF personnel caring for exposed patients removed from a site where a chemical or a biological agent has been released?
- What are the ideal avenues through which HCFs can disseminate information during an event of this type or magnitude?
- What equipment and training requirements can HCFs realistically support for this preparedness? Should public policy provide funding for HCF preparedness?
- Does every HCF in a defined area need this preparedness capability?
- Are there specific chemical and biological agents (in the amounts carried

by contaminated patients presenting to HCFs) that cannot be safely washed into public water runoff?

CONCLUSION

The threat of a large-scale incident involving intentional release of chemical or biological agents in the United States is significant, but currently, no practical models exist for HCF response to a suddenly recognized event requiring the decontamination of mass casualties. The time has come to establish a forum of experts to address the questions presented in this article and elsewhere and to reach a consensus on how to develop and disseminate comprehensive guidelines for HCFs. These solutions should be fully integrated into the community response plan for chemical or biological terrorism.

Precedence for this consensus approach may be found in the method used by the Federal Emergency Management Agency for the creation of the National Urban Search and Rescue System.⁷⁶ Above all, the process must be an operationally oriented cooperative effort and remain uninfluenced by financial gain and unproved technologies.

The threat posed by chemical and biological terrorism must be kept in proper perspective. Disaster preparedness plans must maintain readiness for these events as well as the terrorist use of conventional explosives.^{77,78} Accidental HAZMAT exposures remain even more likely. Robust, effective HCF preparedness integrated with local community planning will help address the more conventional threats.

Disclaimer: The opinions and findings in this article are those of the authors and should not be construed as official policies or positions of the US Department of the Army, US Department of the Air Force, US Public Health Service, or US government.

REFERENCES

1. US Congress, Office of Technology Assessment. *Proliferation of Weapons of Mass Destruction: Assessing the Risks*. Washington, DC: US Government Printing Office; 1993. Publication OTA-ISC-559.
2. *The Emergency Regarding Weapons of Mass Destruction*. Congressional Record; November 8, 1995: S16818-16820. Executive order 12938.
3. Flanagan A, Lederberg J. The threat of biological weapons. *JAMA*. 1996;275:1714-1715.
4. Christen H, Maniscalco P. *The EMS Incident Man-*

- agement System. Upper Saddle River, NJ: Prentice-Hall Inc; 1998:1-15.
5. Nozaki H, Aikawa N, Shinozawa Y, et al. Sarin gas poisoning in the Tokyo subway. *Lancet*. 1995;345:980-981.
6. Sidell F, Urbanetti J, Smith W, Hurst C. Vesicants. In: Zatchuk R, ed. *Textbook of Military Medicine*. Washington, DC: US Dept of Army, Surgeon General, and the Borden Institute; 1997:197-228.
7. Carmeli A, Liberman N, Mevorach L. Anxiety-related somatic reactions during missile attacks. *Isr J Med Sci*. 1991;27:677-680.
8. Nozaki H, Hori S, Shinozawa Y, et al. Secondary exposure of medical staff to sarin vapor in the emergency room. *Intensive Care Med*. 1995;21:1032-1035.
9. Merritt N, Anderson M. Malathion overdose. *J Emerg Nurs*. 1989;15:463-465.
10. Birenzve A. *Inhalation Hazard from Reaerosolized Biological Agents: A Review*. Aberdeen, Md: US Army Chemical Research, Development and Engineering Center; 1992. Report TR-413.
11. Association for Professionals in Infection Control and Epidemiology Bioterrorism Task Force and Centers for Disease Control and Prevention Bioterrorism Working Group. *Bioterrorism Readiness Plan: A Template for Healthcare Facilities*. April 13, 1999. Available at: <http://www.apic.org/html/resc/biomain.html>. Accessed November 12, 1999.
12. Keim M, Kaufmann A. Principles for emergency response to bioterrorism. *Ann Emerg Med*. 1999;34:177-182.
13. Hurst C. Decontamination. In: Zatchuk R, ed. *Textbook of Military Medicine*. Washington, DC: US Dept of Army, Surgeon General, and the Borden Institute; 1997:351-359.
14. Franz D, Jährling P, Friedlander A, et al. Clinical recognition and management of patients exposed to biological warfare agents. *JAMA*. 1997;278:399-411.
15. Inglesby TV, Henderson DA, Bartlett JG, et al, for the Working Group on Civilian Biodefense. Anthrax as a biological weapon. *JAMA*. 1999;281:1735-1745.
16. Henderson DA, Inglesby TV, Bartlett JG, et al, for the Working Group on Civilian Biodefense. Smallpox as a biological weapon. *JAMA*. 1999;281:2127-2137.
17. US Army Soldier Biological and Chemical Command. *Biological Warfare Improved Response Program*. March 10, 1999. Available at: <http://dp.sbccc.army.mil/fs/index.html>. Accessed November 29, 1999.
18. Hall H, Dhara V, Price-Green P, Kaye W. Surveillance for emergency events involving hazardous substances—United States, 1990-1992. *MMWR Morb Mortal Wkly Rep*. 1994;43(SS-2):1-6.
19. Binder S. Deaths, injuries and evacuations from acute hazardous material releases. *Am J Public Health*. 1989;79:1042-1044.
20. US Department of Health and Human Services. *Managing Hazardous Materials Incidents*. Washington, DC: Agency for Toxic Substances and Disease Registry; 1992.
21. Centers for Disease Control and Prevention. CDC recommendations for civilian communities near chemical weapons depots. 60 *Federal Register* 33307-33318 (1995).
22. Carnes S, Watson A. Disposing of the US chemical weapons stockpile. *JAMA*. 1989;262:653-659.
23. Memorandum 35 from President Richard M. Nixon regarding national security decision; November 25, 1969.
24. Memorandum 44 from President Richard M. Nixon regarding national security decision; February 20, 1970.
25. Fullerton C, Ursano R. Health care delivery in the high stress environment of chemical and biological warfare. *Mil Med*. 1994;159:524-528.
26. Bleich A, Shmuel K, Margalit C, et al. Israeli psychological casualties of the Persian Gulf War. *Isr J Med Sci*. 1991;27:673-676.
27. Okumura T, Takusa N, Ishimatsu S, et al. Report on 640 victims of the Tokyo subway sarin attack. *Ann Emerg Med*. 1996;28:129-135.
28. Lillibridge S, Liddle J, Leffingwell S, Sidell F. *Report of the American Medical Delegation to Japan*. Atlanta, Ga: Centers for Disease Control and Prevention; 1995.
29. Haynes V, Coates J. Motive unclear for 2 charged in germ plot. *Chicago Tribune*. February 22, 1998:E98.
30. *United States v Wheeler*, 98 F3d 330 (8th Cir 1996).
31. Torok TJ, Tauxe RV, Wise RP, et al. Large community outbreak of salmonellosis caused by intentional contamination of restaurant salad bars. *JAMA*. 1997;278:389-395.
32. Horowitz S. B'nai B'rith package contained common bacteria. *Washington Post*. April 29, 1997:B2.
33. Bioterrorism alleging use of anthrax and interim guidelines for management—United States, 1998. *MMWR Morb Mortal Wkly Rep*. 1999;48:69-74.
34. Cone D, Davidson S. Hazardous materials preparedness in the emergency department. *Prehosp Emerg Care*. 1997;1:85-90.
35. Landesman L, Leonard R. SARA three years later. *J Prehosp Disaster Med*. 1993;8:39-44.
36. Sorokin E. Mystery mail sickens, briefly shuts Fairfax ER. *Fairfax Journal*. May 2, 1997:A11.
37. Waldron R, Danielson R, Schultz H, et al. Radiation decontamination unit for the community hospital. *AJR Am J Roentgenol*. 1981;136:977-981.
38. General Description and Discussion of the Levels of Protection and Protective Gear, 29 USC §1910.120B (1989).
39. El Sanadi N, Grove C, Takacs M, Daly S, Ellenberger D. A hospital-based, hazardous materials decontamination and treatment unit. *J Prehosp Disaster Med*. 1993;8:337-340.
40. Cancio LC. Chemical casualty decontamination by medical platoons in the 82d Airborne Division. *Mil Med*. 1993;158:1-5.
41. Rivkind A, Barach P, Israeli A, Berdugo M, Richter E. Emergency preparedness and response in Israel during the Gulf War. *Ann Emerg Med*. 1997;30:513-521.
42. Karsenty E, Shemer J, Alshech I, et al. Medical aspects of the Iraqi missile attacks on Israel. *Isr J Med Sci*. 1991;27:603-607.
43. Fehr S. Strike team proposed for quick response to terrorist attack. *Washington Post*. Nov 7, 1995:B3.
44. Nunn-Lugar-Domenici Amendment to the FY 97 Defense Authorization Act, Pub L No. 104-201, Title XIV: Defense Against Weapons of Mass Destruction, Subtitle A: Domestic Preparedness. US Congress; June 27, 1996.
45. *Report to Congress: Response to Threats of Terrorist Use of Weapons of Mass Destruction*. Washington, DC: US Dept of Defense; January 31, 1997.
46. Domestic Preparedness Program, Defense Against Weapons of Mass Destruction. *Technician-Hospital Provider Course Manual*. Aberdeen, Md: US Army CB-DCOM, Domestic Preparedness Office; 1997.
47. Graham B. Anti-terrorism plans termed inadequate. *Washington Post*. October 3, 1998:A9.
48. Hauer JM. Preparing for terrorism involving weapons of mass destruction. Presented at: US Capitol Police Board; February 26, 1998; Washington, DC.
49. HAZ/MAT DQE involved in national preparedness. *HAZ/MAT DQE News*. 1998;6:2.
50. Burgess J, Kirk M, Borron S, Cisek J. Emergency department hazardous materials protocol for contaminated patients. *Ann Emerg Med*. 1999;34:205-212.
51. Londorf D. Hospital application of the incident management system. *J Prehosp Disaster Med*. 1995;10:184-188.
52. Access to PPE. In: *Chemical and Biological Terrorism: Research and Development to Improve Civilian Medical Response*. Washington, DC: National Academy Press; 1999:35-36.
53. Protective measures and handling of casualties. In: *Treatment of Chemical Agent Casualties and Conventional Military Chemical Injuries*. Washington, DC: US Government Printing Office; 1990. FM 8-285, NAVMED P-5041, AFM 160-11.
54. Eitzen E, Pavlin J, Cieslak T, et al, eds. *Medical Management of Biological Casualties Handbook*. 3rd ed. Fort Detrick, Md: US Army Medical Research Institute of Infectious Disease; 1998:appendix B.
55. PPE specifically for biologic agents. In: *Chemical and Biological Terrorism: Research and Development to Improve Civilian Medical Response*. Washington, DC: National Academy Press; 1999:41-42.
56. Adler J. Missile attacks on Israel during the Gulf War. Handout prepared for: National Disaster Medical System Conference on Lifesaving Intervention; May 4-7, 1997; Tampa, Fla.
57. Gong E, Dauber W. Policewomen win settlement. *Seattle Times*. July 11, 1996:B1.
58. Stokes J, Banderet L. Psychological aspects of chemical defense and warfare. *Mil Psychol*. 1997;9:395-415.
59. Sidell F. What to do in case of the unthinkable chemical warfare attack or accident. *Postgrad Med*. 1990;88:70-84.
60. *Medical Management of Chemical Casualties Handbook*. Aberdeen, Md: US Army Medical Research Institute of Chemical Defense; 1995.
61. *Medical Management of Biological Casualties Handbook*. Fort Detrick, Md: US Army Medical Research Institute of Infectious Diseases; 1996.
62. Woolf A, Chrisanthus K. On-site availability of selected antidotes. *Am J Emerg Med*. 1997;15:62-66.
63. Graham B. Clinton to order reserves of germ weapon antidotes. *Washington Post*. May 21, 1998:A1.
64. McClain D. Smallpox. In: Zatchuk R, ed. *Textbook of Military Medicine*. Washington, DC: US Dept of Army, Surgeon General, and the Borden Institute; 1997:539-559.
65. *Hospital Mutual Aid Emergency Preparedness Plan*. Washington, DC: District of Columbia Hospital Association; 1996.
66. *Metropolitan Medical Strike Team Field Operations Guide*. Rockville, Md: United States Public Health Service, Office of Emergency Preparedness; 1997.
67. *Health and Medical Services Support Plan for the Federal Response to Acts of Chemical/Biological (C/B) Terrorism*. Washington, DC: US Dept of Health and Human Services; 1996.
68. Sullivan J, Krieger G. *Hazardous Materials Toxicology*. Baltimore, Md: Williams & Wilkins; 1992.
69. Shapira Y, Bar Y, Berkenstadt H, Atsmon J, Danon Y. Outline of hospital organization for a chemical warfare attack. *Isr J Med Sci*. 1991;27:616-622.
70. Levitin H, Siegelson H. Hazardous materials. *Emerg Med Clin*. 1996;14:327-348.
71. Cox R. Decontamination and management of hazardous materials exposure victims in the emergency department. *Ann Emerg Med*. 1994;23:761-770.
72. Noll G, Hildebrand M, Yvorra J. Personal protective clothing and equipment. In: Daly P, ed. *Hazardous Materials*. Stillwater: Fire Protection Publications, Oklahoma State University; 1995:285-322.
73. Gold M, Bongiovanni R, Scharf B, Gresham V, Woodward C. Hypochlorite solution as a decontaminant in sulfur mustard contaminated skin defects in the euthymic hairless guinea pig. *Drug Chem Toxicol*. 1994;17:499-527.
74. Borak J, Callan M, Abbott W. *Hazardous Materials Exposures*. Englewood Cliffs, NJ: Brady Publications; 1991:145.
75. Sullivan F, Wang R, Jenouri I. Principles and protocols for prevention, evaluation, and management of exposure to hazardous materials. *Emerg Med Rep*. 1998;19:21-32.
76. Barbera J, Macintyre A. Urban search and rescue. *Emerg Med Clin North Am*. 1996;14:399-412.
77. Frykberg E, Tepas J. Terrorist bombings. *Ann Surg*. 1988;208:569-576.
78. Mallonee S, Shariat S, Stennies G, et al. Physical injuries and fatalities resulting from the Oklahoma City bombing. *JAMA*. 1996;276:382-390.